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JACK FOR DISPLACEMENT OF AN ANODE FRAME OF AN ELECTROLYTIC CELL FOR THE PRODUCTION OF ALUMINIUM

Field of the invention

The invention relates to aluminium production by fused bath electrolysis using the Hall-Héroult process. It is more particularly related to devices for the attachment and the displacement of the anodes of electrolytic cells to be used for aluminium production.

State of the art

Aluminium metal is produced industrially by fused bath electrolysis, namely by electrolysis of alumina in solution in a molten cryolite bath called an electrolyte bath, using the well-known Hall-Héroult process. The electrolyte bath is contained in pots called "electrolytic pots" comprising a steel shell lined with refractory and / or insulating materials on the inside, and a cathode assembly at the bottom of the pot. Anodes, typically made of a carbonaceous material, are fixed to a superstructure provided with means of displacing them vertically during the electrolysis process. The assembly formed by an electrolytic pot, its anodes and the electrolyte bath is called an electrolytic cell.

Several devices have been proposed to enable attachment and displacement of anodes with respect to the pot. This invention particularly relates to attachment and displacement devices including fixed structural elements, a frame (called the anode frame) designed for simultaneously lifting and lowering anodes

fixed to the said frame and means of displacing the said frame comprising one or more jacks. French patents FR 1 440 005 (corresponding to American patent US 4 410 786) and FR 2 517 704 (corresponding to American patent US 4 465 578) describe such devices.

The development of electrolytic cells with an increasingly high nominal current, as well as the increase in the current of existing electrolytic cells, increase the weight of assemblies formed by an anode frame and anodes fixed to the anode frame. This increase requires jacks capable of developing higher and higher powers in order to satisfactorily displace the said assemblies.

Therefore, the applicant searched for jacks capable of developing high forces, capable of being inserted in limited and congested spaces in the superstructures of electrolytic cells, and capable of operating close to high current electrolytic cells.

Description of the invention

An object of the invention is a jack comprising a sleeve fitted with an opening, an actuation rod comprising an axial cavity and a thread and capable of moving in the said opening, a drive screw inserted in the said axial cavity and capable of cooperating with the said thread so as to displace the said rod in the sleeve and in the said opening, a toothed drive wheel coupled to the drive screw, and a worm screw that can be connected to the shaft of a motor and that can cooperate with the drive wheel so as to rotate it, and characterised in that the centre-to-centre distance E

between the axis R of the drive wheel and the axis V of the worm screw is between 100 and 350 mm, and in that the reduction ratio RR between the worm screw and the drive wheel is between 300:1 and 80:1.

The applicant found it possible to design a jack capable of simultaneously achieving relatively high powers and pull forces, while remaining within a relatively limited volume, due to the combined characteristics of the jack according to the invention.

The invention can also be used to make an irreversible jack, in other words a jack for which the actuation rod only moves slightly under load, which avoids the need for a built-in brake.

The jack according to the invention is most particularly suitable for the displacement of anode frames of electrolytic cells designed for the production of aluminium.

The invention will be better understood after reading the detailed description of preferred embodiments of the invention, that are described below and that are illustrated using the attached figures.

Figure 1 shows a perspective, truncated view of a typical electrolytic cell.

Figure 2 shows a perspective view of a typical superstructure of an electrolytic cell.

Figure 3 shows a longitudinal section through a jack according to the invention.

Figure 4 shows a cross section along plane C-C in figure 3 through a jack according to the invention.

The electrolytic cells (1) in a fused bath electrolysis aluminium production plant comprise a pot

(2) capable of containing the liquid metal and the electrolyte bath, a superstructure (10) and a series of anodes (3). The superstructure (10) comprises a fixed frame (11) and a mobile metallic anode frame (12). The anodes (3) are provided with a metallic rod (4) to be used for attachment and electrical connection of the anodes (3) to the anode frame (12). The superstructure (10) also comprises at least one jack (100, 100') coupled to the anode frame (12) by connecting rods (20, 21, 22, 21', 22') and levers (30, 31, 32, 33, 34, 31', 32', 33', 34'). The anode frame (12) is moved vertically (upwards or downwards) by the action of the jack(s) (100, 100').

According to the invention, the jack (100, 100') comprises:

- a sleeve (120) provided with an opening (121),
- an actuation rod (140) comprising an axial cavity (141) and a thread (142) and capable of moving in the said opening (121),
- a drive screw (130) inserted in the said axial cavity (141) and capable of cooperating with the said thread (142) so as to displace the said rod (140) in the said sleeve (120) and in the said opening (121),
- a toothed drive wheel (150) coupled to the drive screw (130),
- a worm screw (160) that can be connected to the shaft (210) of a drive motor (200) and that can cooperate with the drive wheel (150) so as to rotate it,

and is characterised in that the centre-to-centre distance E between the axis R of the drive wheel (150)

and the axis V of the worm screw (160) is between 100 and 350 mm, and in that the reduction ratio RR between the worm screw (160) and the drive wheel (150) is between 300:1 and 80:1.

The reduction ratio RR is given by the ratio between the number of turns made by the worm screw (160) around its axis V when the drive wheel (150) makes a complete turn around its axis A. In other words, the reduction ratio RR is given by the number of teeth on the drive wheel (150).

In his search for a solution to the problem that gave rise to the invention, the applicant observed that all constraints imposed by the use of a jack in electrolytic cells required that a large number of parameters had to be taken into account so that it is difficult to predict an acceptable operating zone. In particular, variable parameters originate from at least three coupling levels, namely a first level between the shaft (210) of the drive motor (200) and the worm screw (160), a second level between the worm screw (160) and the drive wheel (150) and a third level between the drive wheel (150) and the actuation rod (140). Variable parameters also originate from relations between the powers involved (particularly input, internal and output powers), required and acceptable speeds (linear and angular), reduction ratios and thread pitches. Furthermore, additional variable parameters originate from efficiency factors for gears and mechanical characteristics of possible materials.

The applicant observed that, surprisingly, it was possible to find a solution to the stated problem by

using configurations and values of parameters significantly different from those normally used in known jacks.

In particular, the applicant observed that a centre-to-centre distance (i.e. a distance between the centre lines) of less than 100 mm would make it difficult to achieve the reduction in the rotation speed required for the drive screw (130) or would make it necessary to insert an additional speed reduction stage between the motor (200) and the worm screw (160) or to use a special motor at low speed (in other words less than about 500 rpm) which would consequently be large and expensive. With this centre-to-centre distance, it would also be necessary to compensate for this lack of reduction on the nut (143) with a smaller thread pitch and consequently thin and weak screw threads. A centre-to-centre distance exceeding 350 mm would increase the jack size to make it unacceptable and hardly compatible with the limited and congested space inside electrolytic cell superstructures. Preferably, the said centre-to-centre distance E is between 150 and 300 mm, and preferably still between 180 and 290 mm.

The applicant also observed that a reduction ratio of less than 80:1 would impose the use of an additional reduction stage between the motor and the worm screw in order to obtain the low displacement speeds (inputs and outputs) of the actuation rod required for the envisaged use. The reduction ratio RR is preferably limited to values of less than 300:1 to avoid the use of large diameter drive wheels (150), which would be

incompatible with the compactness constraint imposed on the invention. The reduction ratio RR is preferably between 100:1 and 250:1. In one preferred embodiment of the invention, the reduction ratio RR is between 140:1 and 200:1.

The applicant has also observed that the worm screw (160) of the jack according to the invention is, or could be, directly engaged on the shaft (210) of a drive motor (200), in other words without an intermediate reduction gear between the drive shaft and the worm screw, which significantly reduces the volume of the jack. Flexible coupling between the motor shaft and the worm screw is possible.

The drive motor (200) is preferably an alternating current motor (typically an asynchronous motor). The power of the motor is typically between 3 and 20 kW (when the motor actuates a single jack, its power is typically between 3 and 8 kW; when the motor actuates two jacks, its power is typically between 5 and 20 kW). The torque developed by the motor is preferably more than 50 Nm and is typically between 70 and 200 Nm. The motor rotation speed is typically between 750 and 1500 rpm and more typically between 1000 and 1500 rpm.

The average diameter D of the drive screw (130) is preferably less than 150 mm so as to limit the outside diameter of the sleeve (120) to acceptable values. The diameter D is preferably between 50 and 120 mm, and more preferably between 75 and 105 mm. A diameter of less than 50 mm would make the drive screw (130) too weak.

The said thread (142) covers all or some of the internal wall of the actuation rod (140). The thread (142) is advantageously formed on a threaded end piece (or nut) (143) that is fixed to the inside end (144) of the actuation rod (140) or is part of it. The screw threads (142) may be single or multiple (for example two parallel threads). The length of the thread is typically equal to at least 10 times the pitch of the drive screw. The thread pitch (142) is preferably between 14 and 20 mm, and is even more preferably between 16 and 18 mm. The applicant has observed that these values of the thread pitch are capable of giving high resistance to force in the envisaged ranges of actuation rod displacement speed.

The dimensions and parameters of the jack according to the invention make it possible to simultaneously and satisfactorily obtain actuation rod displacement speeds and pull forces compatible with the displacement of electrolytic cell anode frames while requiring acceptable rotation speeds of the motor shaft, worm screw and drive screw, preventing the need for slow, large volume and high cost motors.

The rotation speed of the worm screw (160) is typically between 750 and 1500 rpm, and more typically between 1000 and 1500 rpm. The speed of the drive screw (130) is typically between 5 and 15 rpm, and more typically between 7 and 10 rpm. This speed is equal to the speed of the drive wheel when the drive screw is fixed to the wheel or forms part of the wheel. These speeds make it possible to simultaneously and satisfactorily achieve actuation rod displacement

speeds and pull forces that are acceptable for the displacement of anode frames of electrolytic cells.

The jack according to the invention can develop pull forces greater than 100 kN. Pull forces are typically between 150 and 600 kN. Forces of this magnitude are required to displace an anode frame loaded with anodes in the vertical direction without needing large lever ratios in the levers in the superstructure of an electrolytic cell.

The extension or retraction displacement speeds of the rod of the jack are typically between 100 and 300 mm/min., and more typically between 120 and 150 mm/min. These speeds are compatible with regulation by small pulses of the level of the anode frame.

The invention provides a means of using drive motors with a diameter of less than 350 mm, or even less than 250 mm, while having the power and pull forces necessary for the displacement of electrolytic cell anode frames designed for the production of aluminium for which the mass, including the mass of the anodes, is typically several tens of tonnes. The dimensions of the jack according to the invention are typically from 550 to 700 mm transversely with a total length of 1500 to 2400 mm (with the actuation rod in the retracted position).

The drive wheel (150) is mechanically coupled to the drive screw (130). In one preferred embodiment of the invention, the drive wheel (150) is fixed to the drive screw (130), or is part of it, the axis of rotation R of the drive wheel (150) and the axis of

rotation T of the drive screw (130) coincide so as to form a common axis of rotation A.

Preferably, the axis M of the motor (200) and the axis V of the worm screw (160) are coincident. The axis V of the worm screw (160) is typically perpendicular to the axis R of the wheel.

The sleeve (120) advantageously communicates with the casing (110) of the jack to have a single lubricant reserve, typically through openings (114). The axial cavity (141) of the actuation rod (140) advantageously communicates with the sleeve (120), typically through openings (146) formed in its wall, so as to enable lubrication of the thread. The outside end of the actuation rod (140) is provided with an attachment means (145).

The jack (100, 100') preferably comprises a seal (122) between the actuation rod (140) and the sleeve (120). It has been found that it is advantageous to use a rigid sleeve (120) rather than a bellows-shaped sleeve, usually fitted on conventional jacks with a large stroke. A bellows-shaped sleeve, that folds and unfolds continuously during use, has the disadvantage that it is sensitive to abrasion caused by abrasive materials such as alumina in suspension in the environment of an electrolytic cell and that could be deposited in the folds of the bellows.

The sleeve (120) advantageously comprises a long tubular part (typically with a length approximately equal to the stroke of the actuation rod inside it) in order to guide displacements of the actuation rod.

The drive wheel (150) of the jack according to the invention is preferably supported on at least one bearing (151, 152). The bearing may be located on the side opposite the drive screw (130) or between the wheel and the drive screw.

The jack attachment means (111) may be placed on the rear part (112) of the jack, in other words the part of the jack opposite the actuation rod (140), or on the front part (113) of the jack, typically on the sleeve (120).

The drive motor (200) of the jack may be specific to one jack or it may be common to two or more jacks. If it is common to two jacks, the motor shaft typically passes through and is connected to a jack on each side of the motor. If the motor shaft is connected to two or more jacks, the drive device can be more compact and the jacks can be synchronised.

The jack according to the invention is most particularly suitable for use in an electrolytic cell for the production of aluminium. Thus, another purpose of the invention is the use of a jack (100, 100') according to the invention for the displacement of an anode frame (12) of a superstructure (10) of an electrolytic cell (1) designed for the production of aluminium.

Another object of the invention is a superstructure (10) to be installed in an electrolytic cell (1) for the production of aluminium and comprising an anode frame (12) and at least one jack (100, 100') according to the invention to displace the said frame.

Another object of the invention is an electrolytic cell (1) provided with such a superstructure (10).

The said electrolytic cells (1) may operate at intensities typically more than 300 kA, or even more than 400 kA, and possibly more than 500 kA.

List of marks

1	Electrolytic cell
2	Pot
3	Anode
4	Anode rod
10	Superstructure
11	Fixed frame
12	Anode frame
20, 21, 22, 21', 22'	Connecting rods
30, 31, 32,..., 31', 32',...	Levers
100, 100'	Jack
110	Jack casing
111	Attachment means
112	Jack rear part
113	Jack front part
114	Opening
120	Sleeve
121	Opening
122	Seal
130	Drive screw
140	Actuation rod
141	Axial cavity
142	Thread
143	Threaded end piece (nut)

144	Inside end of the actuation rod
145	Attachment means
146	Opening
150	Drive wheel
151, 152	Bearings
160	Worm screw
200	Drive motor
210	Motor shaft

A	Jack axis
D	Drive screw average diameter
E	Reduction centre-to-centre distance
M	Motor axis
R	Drive wheel axis
RR	Reduction ratio
T	Actuation rod axis
V	Worm screw axis